PREDATORY AND SEXUAL BEHAVIOR OF THE SPIDER *SICARIUS* (ARANEAE: SICARIIDAE)*

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For a period of over 20 years, from 1911 to 1933 (Bonnet, 1945), Gerhardt published observations on the sexual behavior of spiders, describing sperm induction, charging the pedipalps with sperm, as well as mating. The observations (Gerhardt, 1924, 1927, 1930, 1933) concerned representatives of all available families with the hope of obtaining comparative data. Different groups of spiders have different methods of sperm induction and different mating positions. Gerhardt was more interested in the mechanical aspects of mating than in courtship behavior. A helpful summary (in English) of the observations of Gerhardt, Bristowe and others is provided by Kaston (1948). Only in the last few years have there been some experimental studies, including observations on the copulatory behavior of spiders after removal of their palpi (Rovner, 1966, 1967). Surprisingly, courtship continued normally although both pedipalps had been amputated in the penultimate instar and neither sperm induction nor copulation was possible.

During sperm induction, the spider makes a web with silk from the posterior spinnerets. A small area in the web, a substrate, is prepared with silk from spinning glands in the epigastric area (Melchers, 1963; Marples, 1967). On this substrate a drop of sperm is deposited. The sperm is drawn into a duct within the pedipalp of the spider, perhaps by resorption of a fluid previously secreted by the surrounding glands (Cooke, 1966). In some haplogyne spiders (which lack an epigynum, a plate with copulatory pores separate from gonopores), both pedipalps are inserted into the drop simultaneously; in Orthognatha (the "tarantulas" of American parlance) and most other spiders, alternately. Some spiders attach the drop below the web and stand above while charging the pedipalps; others deposit the drop on the upper surface and reach around the edge to charge the pedipalps through the web. The pedipalps are recharged after mating.

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There is an enormous literature on courtship, partially summarized by Kaestner (1965, and in press). The possible mating positions are summarized by Kaston (1948). In the Orthognatha and many haplogynes, the male stands with his body at an angle to that of the female, or with his dorsum applied to her venter, the partners facing opposite directions. In others, mainly hunting spiders, the male mounts the back of the female, facing in the opposite direction. In many web spiders he crawls under the female, venter to venter, facing the same direction. In others the male and female position themselves venter to venter facing opposite directions. In some, the female lies on her side with the male over her. In most haplogynes both pedipalps are inserted at the same time; in other than haplogynes only one is used or, more commonly, the pedipalps are alternated.

Dabelow, in a recent paper (1958), described differences in mating position of different "races" of the haplogyne *Scytodes thoracica* from the Mediterranean, Dalmatia and central Europe. The female has sclerotized grooves on the venter of the abdomen which receive the jaws of the male during copulation. Females of the Mediterranean race took a vertical position with the male horizontal. In the central European race both tended to assume a vertical position facing the same direction. In the Dalmatian race the male crawled under the female and mated venter to venter. As no taxonomic revision of European *Scytodes* exists, it is difficult to interpret the results. The variation in mating position might reflect geographical variation or the "races" may actually represent separate species. Whatever the factors, apparently this behavior is not as conservative as formerly thought. A *Scytodes* sp. from Arizona was observed by W. Eberhard (unpublished) to take still another position. Its chelicerae did not bite into the sclerotized abdominal grooves at all during mating.

One family not represented in any of these studies and never heretofore recorded is the Sicariidae, a small family of spiders mainly of the southern hemisphere, Africa and South America. Sicariids, as an adaptation to their mainly arid and hot desert habitat, bury themselves in sand (Reiskind, 1966) and sand grains from their surroundings adhere to their setae, giving the spiders the color of their background. *Scytodes* is often erroneously placed by European arachnologists in the haplogyne family Sicariidae. Most European arachnologists are completely unaware of the nature of *Sicarius,* having seen only preserved specimens. Judging by the observations to follow, the families Scytodidae and Sicariidae, while related, are nevertheless distinct.

A taxonomic revision of the family Sicariidae has never been made. Such a study would be time consuming and difficult — the holotypes of the numerous names would have to be consulted in various South American museums. The species in our cultures are thus labelled no. 1 (from Tucumán Province, Argentina) and no. 2 (from Lima, Peru). Voucher specimens have been placed in the Museum of Comparative Zoology. The life history observations recorded here come from culture no. 1.

FEEDING

Sicarius is a powerful spider that feeds on passing insects, rapidly emerging from the sand when disturbed. The prey is not chewed but, like the prey of many spiders, apparently liquified inside its integument and then sucked out. No use at all is made of silk in prey capture. Small prey (e.g. house flies, mealworms) are taken along when the spider digs itself into the sand, and are never left and picked up later. However, a grasshopper 1 1/2 times as long as *Sicarius* was bitten and left, to be attacked again shortly afterwards. When the prey was somewhat subdued the spider began feeding, changing the place of biting and turning the prey during the next five hours. The prey was then left during the evening, and the spider buried itself; the next morning, the spider emerged and went straight to the grasshopper shell about 5 cm away, bit into it and fed for a while. Whether it fed during the night is not known. (It is doubtful that sicariid eyes produce a picture image.)

MATING

Of the contents of one egg case raised, four specimens matured: one female and three males. After two males matured in June 1967, they were "restless" and often were seen against the walls of their plastic container, rarely buried. On the 20th of July, 1967, one male was placed with a female, one with an immature male thought to be an adult female. They buried themselves after the disturbance. The male placed with the juvenile specimen showed no interest in it. The juvenile molted on 21 October 1967, and turned out to be a male.

The other male, however, surfaced after about two hours and walked about. Suddenly he stopped and began to dig with the front legs, thus exposing the posterior end of the abdomen of the female, who was facing the opposite direction. After the female was dug out or in part emerged from the sand (at about 15:30), the male and female stood face to face, the fronts of their carapaces touching. The male gently felt the dorsal abdomen of the female with his long legs.

Fig. 1. *Sicarius* sp. mating; each individual is about 18 mm in body length.

Then with a sudden movement the male turned the female into mating position, clamping her down with his legs (Fig. 1), and both pedipalps were inserted immediately (at 15:35). The pedipalps "wiggled" slightly. Once in a while the female made a slight motion (Fig. 1). After 18 minutes (15:53) the animals suddenly separated, the female moved about 7 cm to the side and rapidly dug herself in. The male stood for about 30 seconds, then moved off about 20 cm and buried himself.

On 17 Setpember 1967, at 20:00, the same male was placed with the same female again. He moved slowly about, but stopped when he touched the partly exposed abdomen of the female. Suddenly he pulled her out of the sand sideways; the female did not resist. The male went through the same motions described above. For a short time before turning the female on her back the front ends of the male's and female's carapaces touched. The spiders separated 30 minutes after starting copulation, moved in opposite directions, but did not bury themselves (perhaps due to relative darkness). Unfortunately no movie camera was available to record the sequence.

SPERM INDUCTION

The night following the first mating, neither of the mated spiders appeared active. Both remained buried. At 22:30 the following night (21 July 1967), I was surprised to find the male hanging in a web, for I had not seen any use of spinnerets or silk before. The web consisted of very coarse strands of unequal width, diagonally from the side to the lid of the container, attached below to a vertical cardboard partition, above by several threads to the screen lid. The threads, later examined under the microscope, consisted of at least 10 strands matted together into a ribbon, flat in places. The male was hanging head up (Fig. 2), and the alternate forward and back movements of his pedipalps suggested that this might be the sperm web. A minute later the spider slid down and both pedipalps touched a yellowish-white droplet at the junction of the silk threads (Fig. 3). Both pedipalps touched the droplet at the same time, but did not move at all. The lights were turned on without apparently disturbing the spider (previous observations had been made with a dim flashlight). An attempt to lift the lid (at 22:45), with the hope of photographing, however, disturbed the silk threads. The spider jumped down onto the sand and buried himself. The lack of threads with other males suggests that the web was destroyed and eaten after use.

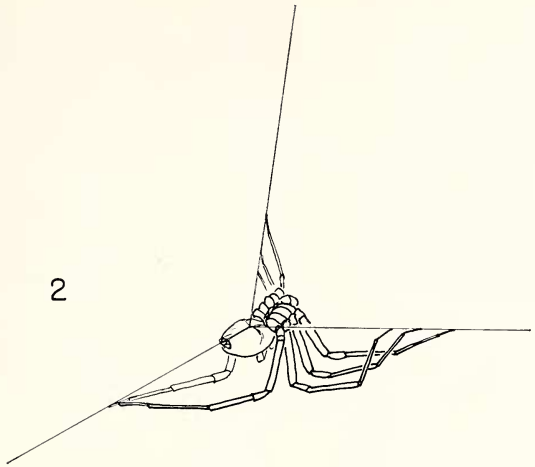

Fig. 2. Male depositing sperm on sperm web.

LIFE SPAN

From a newly hatched eggcase given to me by Dr. W. K. Weyrauch in February 1965 in Tucumán, we reared two males and one female that molted to maturity during June 1967 and one male that matured in October 1967. The individuals took more than two years to mature. Individuals of species 2 from Lima, Peru, were 1 1/2 years old and less than half grown in August 1967. An adult individual collected on 2 April 1965 (under a log in pasture near Santiago del Estero) appeared moribund in July, 1967; it had not fed for some time, no longer buried itself, and looked emaciated. After placing it in alcohol, I discovered it was a male. (Male sicariids differ from females by having longer legs and by modifications of the pedipalps that are not readily apparent). As far as we know, the individual had never molted, had lived at least two years beyond reaching maturity, and was probably at least four years old. After killing the male, we discovered that its container had become moldy, a condition that would be injurious to most spiders; thus it may have been moribund not from old age, but from poor laboratory conditions.

DISCUSSION

Although related, sicariids are very different from scytodid spiders. While the slow scytodids overpower their prey by spitting a viscid, entangling substance, the sicariids are strong, fast moving predators

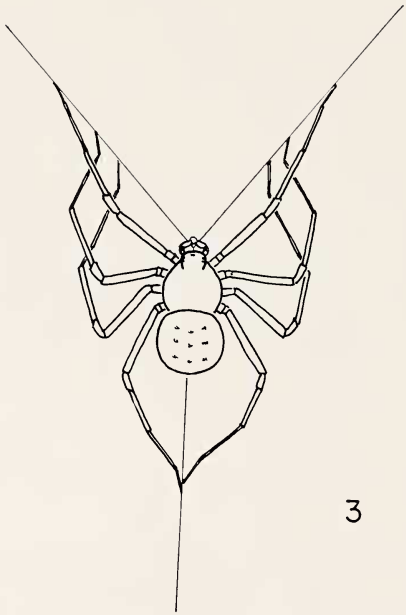

Fig. 3. Male taking up sperm into pedipalps.

that overpower their prey with force and poison. Both sicariids and loxoscelids lack the adaptations of scytodids for their unusual method of prey capture: the high-domed carapace containing the glands used for spitting, and the short, stout fangs with the aperture of the gland duct at their midpoint. (The Loxoscelidae are also at times placed in the Sicariidae, but probably with more reason than the Scytodidae.)

The sicariids courtship act of digging the female out of the sand is probably unique among spiders, but the mating position is similar to that of scytodids, a group in which there is some variation (see above). As in other haplogyne spiders (but unlike orthognath "tarantulas"), both pedipalps are inserted into the gonopore at the same time.

Another habit shared with other haplogyne spiders, but not with orthognath "tarantulas", is that both pedipalps are inserted simultaneously into the sperm drop during sperm induction. An exception is the haplogyne dysderid, *Harpactes rubicundus,* which uses the method exhibited by most spiders, continuously alternating the pedi-

palps for sperm filling. Members of the orb weaver genus *Tetragnatha* use the haplogyne method of sperm induction (Gerhardt, 1927), although the absence of an epigynum in *Tetragnatha* is believed secondary. *Filistata,* though it lacks an epigynum, is considered (there abides a controversy) to belong to a separate line of evolution because of the presence of a cribellum. The *Filistata* male alternates the pedipalps in mating and in sperm induction, as do the orthognaths (Gerhardt, 1930).

There is little literature on the significance of longevity of spiders. But it is striking that spiders with genitalia considered primitive are long lived, those with more typical genitalia are short lived. A short life span of one or two seasons and rapid succession of generations must be of selective advantage, as it is a charateristic of the most successful groups of spiders. Selective advantages might be larger numbers of progeny, increased number of generations, and ability to colonize new situations, especially areas with short seasons, etc. Table I summarizes the available data on longevity of spider species with simple genitalia.

Primitive groups of hypochilid spiders, however, are short lived. Adult *Hypochilus gertschi* disappear in the fall, adult females reappearing in July. Probably it takes two years to mature (W. Shear, in letter). During an autumn visit to Chile (March, 1965), only juveniles of *Thaida peculiaris* (=*Austrochilus manni*) were found, no adults.

Adult Orthoganatha (e.g. Theraphosidae) molt once or twice a year during most of their long lives, except during the last year or two. Haplogyne spiders do not molt after reaching maturity. In molting, presumably, spiders shed also the lining of the seminal receptacles and with it any stored sperm. Thus, it is rare for a captive theraphosid to produce an egg sac unless the animal is a recent captive. In contrast, some haplogyne females even after years of captivity may still produce fertile egg sacs from previous matings.

Another specialization of scytodids that separates the family from other groups should be pointed out. On the venter behind the gonopore the female has sclerotized grooves into which the fangs of the male are usually inserted to hold the female during mating; this structure is not present in sicariids or loxoscelids. Perhaps these grooves represent a preadaptation toward the evolution of an epigynum (the plate bearing separate copulatory pores which lies in front of the gonopores) present in most higher spiders.

	time to maturity	male life span beyond maturity	total life span of female	molt as adults
Theraphosidae	ca. 3 yr.	up to 1 yr.	to 20 yr.	♀♀ yes
Sicariidae[1]	2+ yr.	2+ yr.	4+ yr.	no
Loxoscelidae	1 yr.	1-2+ yr. *(laeta)*[3]	2 1/2 yr. *(reclusa)*[2] 4-6 yr. *(laeta)*[3]	no
Scytodidae[4]	1-1 1/2 yr.	max. 1 yr.	3 yr.	no
Diguetidae[5]	?	?	1+ yr. beyond maturity	no
Plectreuridae[1]	2-3 yr.	?	? 4+ yr.	no
Dysderidae[6]	1 1/2 yr.	at most 1 1/2 yr.	4-5 yr.	no
Most higher spiders and most cribellates	less than 1 yr.	usually die after mating	at most 1 season after maturity	no
cribellate Hypochilidae[7]	? 2 yr.	die after mating	2-3 months	no
cribellate Filistatidae[8]	? 1-2 yr.	die after mating	5-7 yr.	no

Table I. Length of life of spiders considered "primitive" on basis of their simple genitalia.

[1]personal observation
[2]Hite, 1966
[3]pers. comm. Mrs. F. Coyle, A. Spielman, R. E. Wheeler from colonies kept at Cambridge, Mass.
[4]Dabelow, 1958, on *Scytodes thoracica*
[5]pers. comm. W. Eberhard
[6]Cooke, 1965a, b, on *Dysdera crocata.*
[7]pers. comm. W. Shear
[8]Gerhardt, 1930; Lowrie, 1965

In the Pholcidae, this same structure, a swollen area held by the male with his chelicerae, is in front of the gonopores in place of the epigynum of other spiders. However, as indicated by this genital structure of the female and the unusual pedipalp structure of the male, Pholcidae are not closely related to other spiders. Further evidence for this comes from the method of sperm induction, quite different from that of any other spiders: the sperm drop is taken into the mouth aided by the third legs and from there to the palps. As in other haplogyne spiders, both pedipalps are inserted simultaneously into the female gonopore (Gerhardt, 1927).

A unique, as yet unmentioned, behavioral character of sicariids is the eggsac. Made of sand grains, it resembles a mud-dauber nest rather than a spider eggsac (Levi and Levi, 1968, p. 28). The method of construction is unknown. Scytodids carry their eggs in a loose sac; loxoscelids attach their eggs, wrapped in very few threads, in their webs, as do plectreurids. Dysderids keep their eggs at the inner end of the tube with no silk around the eggs (*Ariadna* and *Dysdera*). Diguetid eggs are contained in strong silk sacs within a strong silken tube.

SUMMARY

Sicarius feeds by overpowering passing insects. No use is made of silk in feeding; the prey seems to be slowed down by poison. The male begins courtship by digging the female out of the sand and stroking her. The mating position was observed (Fig. 1); both pedipalps were inserted simultaneously. A female will mate repeatedly. In recharging the pedipalps, both were dipped simultaneously into the sperm drop on a specially made web and held in the drop without visible movement. In their long life span sicariids resemble other haplogyne spiders (although there are some exceptions). In its behavior, *Sicarius* resembles *Loxosceles* more than *Scytodes*. Construction of the unusual eggsac of *Sicarius* has not been observed.

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